Reply to Referee Comment 2

Thank you very much for your detailed review and suggestions. At first, we want to reply to the two general issues mentioned in the comment:

1)
We agree that precise knowledge of the shortcomings (and advantages) of these sensors is very important. We would argue that a good overview, sufficient in most cases, can be extracted from the respective datasheets, and a high-level comparison for our specific setup is already provided in Table 1. For a more in-depth comparison against professional-grade instruments, we have added a few sentences including relevant references in Section *2.1 Sensors:*
- Automotive lidar vs TLS comparison (Goelles et al., 2022; Perks et al., 2024) at the end of the *Lidar* subsection:

This trade-off has been quantified directly against professional-grade TLS. Goelles et al. (2022) report range accuracies on the order of 5 cmfor the same sensor class against a Riegl VZ-6000 on Lambertian targets, representative of most natural surfaces encountered in geoscience monitoring, with larger errors of up to 25 cm observed only for retroreflectors. Perks et al (2024) similarly found a Livox Mid-40 capable of centimeter-scale change detection consistent with a Riegl VZ-4000 over a three-month field deployment, at a fraction of the cost.
Notably, newer Ouster revision 8 models reportedly offer over 350 m range, improved noise suppression, and colored point clouds (Ouster, 2026). Livox even claims a range of up to 1000 m for the new Avia 2 model in focus mode (Livox, 2026a).

Goelles et al. (2022): https://doi.org/10.5194/gi-11-247-2022
Perks et al. (2024): https://doi.org/10.1029/2024EA003514
Ouster (2026): https://ouster.com/rev8
Livox (2026a): https://www.livoxtech.com/avia-2

- Comparison of our automotive radar's specifications against a purpose-built avalanche/debris-flow Doppler radar (Schimmel et al., 2017) at the end of the *Radar* subsection:

Purpose-built hazard-monitoring radars offer a useful point of comparison. For example, the pulse-Doppler radar used to monitor debris-flow surge dynamics by Schöffl et al. (2023) reaches a much longer maximum range of up to 2000 m, but with a coarser range resolution (15-43 m) and a lower update rate (about 4 Hz) than the automotive radar, reflecting its design for tracking surges along an entire torrent rather than fine-grained detection at short range.
Modern automotive radar sensors offer considerably longer ranges. Bosch's latest-generation automotive radar, for example, reports a detection range of up to 300, m (Bosch Mobility, 2026). Unlike the lidar market, however, specifications across manufacturers are less standardized, and these radar sensors are typically sold exclusively through the automotive supply chain, making them considerably harder for research groups to access than comparable lidar sensors.

Schöffl et al. (2023): https://doi.org/10.1029/2023JF007171
Bosch Mobility (2026): https://www.bosch-mobility.com/en/solutions/sensors/radar-sensor/

2)
This point aligns with RC1, and we agree that power consumption and weight is important information which we added in the revised paper.
Regarding power consumption, see our reply to Referee 1. Additionally, we added the weight specification in a sentence at the end of section 2.2:

The primary and extension units weigh approximately 2.2 kg and 1.9 kg, respectively, for a total system weight of 4.3 kg, including connecting cables.

All specific comments appear to be very well thought out and have been addressed in the following way:

Line: 25-26: Add short explanations or example references about what you mean by „advanced use cases“ versus „traditional monitoring“
We agree that this should be clarified, we suggest:

“These new systems provide a multitude of new opportunities, not only in advanced use cases such as Simultaneous Localization And Mapping (SLAM) (Balasa et al., 2021), or autonomous UASs navigation (Liang et al., 2023), but also for more traditional, fixed-location monitoring applications.“

Balasa et al. (2021): https://doi.org/10.1109/ECAI52376.2021.9515047
Liang et al. (2023): https://doi.org/10.1371/journal.pone.0287177

Line 27: „ ... the high temporal resolution of automotive sensors ...“ => depending on the sensor high temporal resolution can mean everything from days to milliseconds. I would add a short explanation to what temporal resolution you refer.
“The high temporal resolution, in the sub-second range, of automotive sensors enables the observation...”

Line 32: „... about 10Hz ...“ In the rest of your paper you state 20Hz
Thank you for point out this inconsistency, we changed it to 20 Hz as well.

Line 76-77: I think you could strengthen your argument by precisely stating the gaps that cannot be solved by current techniques. For example, you could add case studies where current measurements are insufficient or where a number of assumptions have to be applied.
Thank you for this suggestion. We have added a short paragraph listing specific examples in which continuous monitoring has led to a significant improvement in results.

“At the same time, new research questions have emerged within our group, particularly those related to atmospheric processes, snow dynamics, and mass movements. Addressing these questions increasingly requires resolving processes that periodic, campaign-based measurements cannot capture. In debris-flow monitoring, for example, dynamics such as the discrepancy between surface and front velocities only emerge at sub-second acquisition rates

(Aaron et al., 2023), while a conventional pre- and post-event TLS survey captures only the net volumetric change. Similarly, as the interval between repeated TLS surveys of a rockfall site widens from hourly to monthly, temporally clustered small events increasingly merge into single observations, and the detected volume contribution from small (< 0.1 m3) events falls from 98 % to 67 % (Williams et al., 2018), which is why continuous rather than repeat scanning is needed to track individual rockfall or avalanche (Goelles et al., 2025) activity as it occurs. This type of research often takes place…"

Line 94-104: These two paragraphs are partially redundant because you state multiple times that certain devices are built to be waterproof or resistant to bad weather. I would also remove the sentence in L.96-98 as you stated this already before.

We agree that these paragraphs sounded redundant. We believe this was primarily because two concepts were being mixed. One is sensor performance, i.e. data quality, under adverse weather conditions, and the other is the robustness of the hardware. Both aspects are important for reliable monitoring, so we have rewritten the section to better distinguish between the two:

"Sensor performance in adverse weather, i.e., the quality and reliability of the acquired data itself, is a major field of research in the automotive industry and for (semi-)autonomous and remote control systems in general (Zhang et al., 2021; Kutila et al., 2018; Jokela et al., 2019). Understanding these performance limitations is equally important for continuous environmental monitoring.

Independent of data quality, a sensing system intended to be truly versatile and autonomous must also physically withstand diverse weather conditions (e.g., hot, cold, wet, dusty). Accordingly, the hardware must be waterproof, dustproof, and capable of withstanding extreme temperatures. Sensors developed for the automotive industry prove to be an ideal fit for this requirement, since they are built for all weather conditions and are usually rated IP68 and above (dust and water proof according to the International Protection rating). For the data logging component, an efficient computing platform is essential,

not only to conserve energy and extend battery life for remote deployments, but also to minimize heat generation. A system that functions without active cooling can be fully sealed within a waterproof enclosure. Conversely, in cold conditions it can be beneficial to have some heat-generating components to prevent damage. Ultimately, we expect the resulting platform to serve as a foundation for future monitoring efforts across geosciences more broadly."

Line 121: „compare 3" I guess you mean: compare Figure 3?

Yes, this should read "compare Figure 3". We corrected this in the text.

Line 123-124: „SLAM algorithm LIO-SAM" a reference could be added here

We added the link to the GitHub page: https://github.com/TixiaoShan/LIO-SAM

Line 185: I would simply state that radar can penetrate adverse weather conditions (to a certain degree) which is not possible for optical sensors

We suggest:

“The automotive radar sensor was included to assess its potential capabilities and limitations for environmental applications, particularly due to its capability to penetrate adverse weather conditions to a certain degree, where optical sensors like lidar and cameras may be limited.”

Table 2: It is for sure interesting to see the actual costs of each component. The most expensive category is „Other small parts“. This is stunning because the parts mentioned in brackets should not be very expensive (except maybe the waterproof housing). In fact, this category is responsible for 60% of the total budget. Can you please elaborate on this?
Good point! We will make sure to break down “Other small parts” in more detail. Also included in this point is the GNSS Hat which already costs around 300 EUR. Next to the aluminium housing, the IP68 rated connectors, dust caps and cables for power and data are relatively expensive (see for example: https://at.rs-online.com/web/p/ethernet-verbinder/1116747).

Figure 2 & 3: a scalebar would be nice
Agreed. We added a scalebar in both Figures.

Line 261-262: „…ROS decouples application logic from the communication layer and provides configurable Quality-of-Service options…“ => Not sure what you mean here, maybe add a more detailed explanation
We understand that this sentence is not very well understandable in the context of this paper. Our aim is to convey the publisher-subscriber nature of ROS, which makes it easy to add/remove new sensors (nodes) without a change to the underlying framework. We suggest the following improvement:

“By leveraging Data Distribution Service (DDS) as its underlying middleware, ROS decouples application logic from the communication layer, so sensor nodes can be added, removed, or replaced independently, and offers configurable Quality-of-Service (QoS) options to trade off reliability against latency per data stream, e.g., best-effort delivery for high-rate lidar data versus guaranteed delivery for GNSS fixes (Macenski et al., 2022).”

Line 317: „…software like Lichtblick …“ Please add a reference here, e.g. github link
We added the GitHub link: https://github.com/lichtblick-suite/lichtblick

Line 332-333: „For us, MOSEP, and application specific derivatives of it, evolved to a universal measurement platform and we believe it to be a generally useful tool in geosciences.“ => This sounds like a conclusion which you draw before demonstrating your casestudies to the reader. I would remove this sentence (also the next one on financial risks) and rather focus on the potential applications. This would build a nice bridge to the specific usecases you show in the subsections. Besides, there is a small spelling mistake in „usefull“.
We agree, that this belongs to the conclusion. We rewrote the intro to this paragraph:

“MOSEP, and application-specific derivatives of it, are designed as a flexible measurement platform for a wide range of geoscientific monitoring tasks. Recordings can be triggered once a day or up to 10 times per second, making the system flexible enough…”

Line 353-355: Was the main objective to detect and measure the distance to the approaching car? Could be stated more clearly.

Agreed, we changed the sentence to align with the goals of the campaign as stated earlier in text ("how varying rain intensities affect sensor perception distance and data quality") and as later confirmed in the results:

"The primary objective of the campaign was to assess how heavy rainfall affects the performance of the perception sensors themselves, in particular detection range, data quality, and the rate of false-positive detections, using an approaching vehicle as a controlled test target."

Line 381ff. You state that penetration below water level is possible but depends on incidence angle and distance? Could be stated more clearly.
We slightly rewrote the paragraph to be more clear about the apparent returns from below the water surface. Please refer to our response to RC1 for more details.

Line 454: „MOSEP requires a certain level of technical expertise …" Here and in the next sentence you mention a technical documentation (user guide?). Is this online available? If so, please include a link (e.g. in data availability statement). Another option could be to add the documentation as supplementary materials.
Thank you for pointing this out. All the documentation is available on GitHub. A link to the collection of repositories is already mentioned in the *code availability statement*.